Case Study 152

Energy efficiency in advance factory units

South Wales Cables and Accessories Ltd
Neath
West Glamorgan

- Warehouse for electrical cables
- 450 m^2 semi-detached, 20% as two-storey offices
- Opportunity for retrofit insulation of dividing wall
- Good fabric insulation
- Thermography survey in construction contract
- Combination boiler for office heating and hot water
- Roof extract fan with motorised shutters for summer ventilation

Background

This Case Study illustrates a building with heated office areas adjacent to unheated warehouse space in a flexible-use building.

Developed for leasing by the Welsh Development Agency (WDA), the semi-detached building was designed by James, Davies and Frost Architects and constructed by Mowlem South Wales Ltd.

The occupier uses it for the storage and distribution of electrical cables and associated accessories. There are seven employees.

Total gross floor area is 448 m^2 (4820 ft^2). The two-storey offices comprise 20% of the total area with 53 m^2 on the ground floor and 37 m^2 on the first floor, while the remainder of the ground floor, 358 m^2, is used for storage.

The building fabric design conforms to the WDA policy of developing cost-competitive, high quality buildings. Features designed to give good insulation performance for the external fabric of the building are incorporated, along with detailing to control air leakage.

The building was completed in February 1989 at a cost, including the office services, of about £313/m^2. This is in the lower range of the Building Cost Information Service average building prices for 'advance factories – generally, up to 500 m^2 floor area'. The tenant took up occupation in January 1990.

Summary

The developer pursues a policy of cost-effective energy efficiency in the construction and fit-out of advance factory units, and this is reflected in this building.

"Illustrates a building with heated office areas adjacent to unheated warehouse space in a flexible-use building"

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Steel cladding, used for the majority of the building superstructure, incorporates an optimum level of insulation which exceeds the requirements of the 1985 Building Regulations without imposing significant extra structural costs. **An infra-red thermography survey was carried out as part of the construction contract to confirm built quality.**

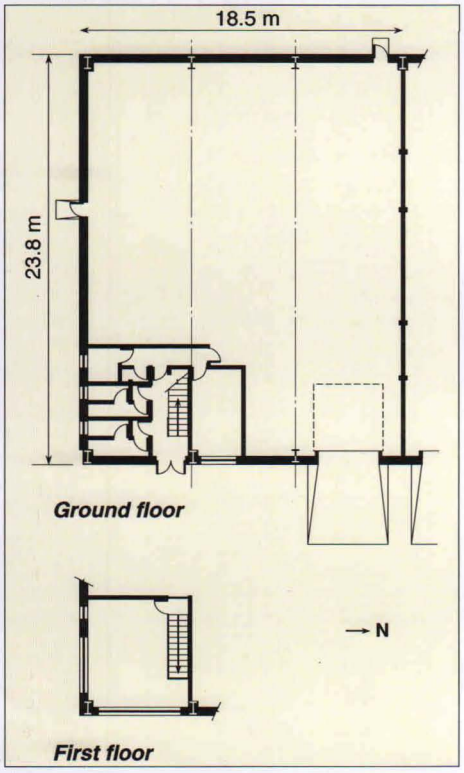
Building fabric tests, undertaken as part of the Case Study, indicated generally even thermal performance, confirming good construction standards.

The office area heating uses a gas-fired combination boiler to supply a radiator system and domestic hot water. The storage area is unheated.

Total energy consumption in 1990/91, normalised to standard degree-days, was 27 518 kWh at an actual cost of £800.

The energy used for office space heating corresponded closely to that predicted by calculation, confirming that the fabric and heating system performed as designed. It was estimated that heat loss through the internal partition to the unheated storage area increased the design condition gas consumption for office space heating by 52% compared with a heated storage area. This highlights the opportunity for further improvement by addition of internal insulation in the unheated storage area.

However, for the more usual situation of heating of the storage area, the normalised energy consumption for the whole building was estimated at 154 kWh/m^2, a 27% saving over an average warehouse, and corresponding approximately to the EEO 'good' rating for heated warehouses.



Floor plan

Side view

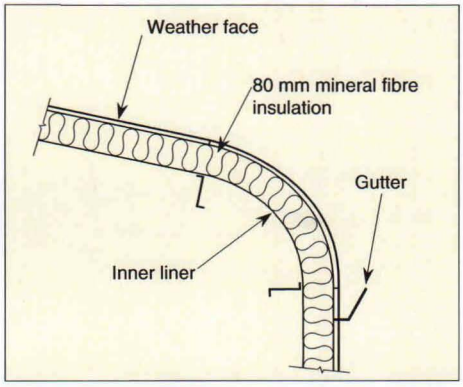
Building Design and Construction

The roof and walls employ a site-assembled steel cladding construction incorporating 80 mm thick mineral wool fibre insulation with integral vapour barrier and internal metal liner sheet. The U-value of 0.4 W/m^{2}K exceeded the minimum of 0.6 W/m^{2}K required by the then current Building Regulations. The outer sheet colour is grey, minimising thermal expansion problems.

Site-assembled, double-skin rooflights, comprise 10% of the roof area. Curved eaves provide continuity of insulation. External gutters are used, reducing the occurrence of condensation and thermal bridges. The height to eaves is 5.5 m.

The front elevation comprises a half-height masonry wall with cladding above. The U-value of the masonry is 0.6 W/m^{2}K. An insulated overhead goods door, which is manually operated, opens onto the storage area. This area is bounded by a dado-height blockwork wall to protect the liner sheet at low level and to provide space for mounting services.

The offices are contained in a two-storey block constructed from cavity blockwork in one corner of the storage area. All windows and entrance doors are double-glazed and aluminium framed. Solid wood fire escape doors are used in the rear elevation. The floor is an uninsulated 200 mm thick reinforced concrete slab.



Detail of curved eaves

Building Services
Office Area

The office heating and lighting were installed by the developer. A two-pipe radiator system is fed by a 19 kW output gas-fired combination boiler, wall-hung in the storage area adjacent to the ground floor office. A fan-assisted balanced flue is used. The boiler also supplies, on demand, domestic hot water to the basins and sinks. It is controlled by a 24 hour time clock giving a fixed time start. Space temperatures are controlled by radiator valves. The heating is manually switched off at the weekend to avoid unnecessary running.

Conventional, surface-mounted, twin-batten fluorescent light fittings are installed.

Building Services
Storage Area

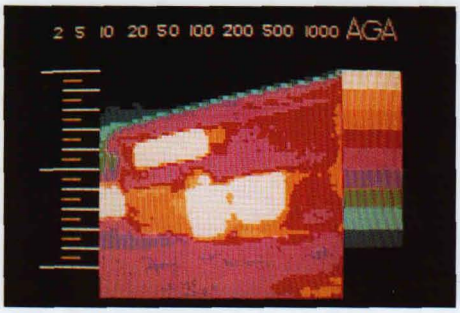
No heating is installed in the storage area. Summer ventilation of 4 air changes per hour is provided by a roof extract fan centrally mounted in the storage area roof. The incorporation of motorised shutters on the fan provided positive closure of the fan aperture, preventing air leakage when not in use.

Conventional fluorescent luminaires augmented the four high pressure sodium (SON) fittings installed by the occupier in the storage area.

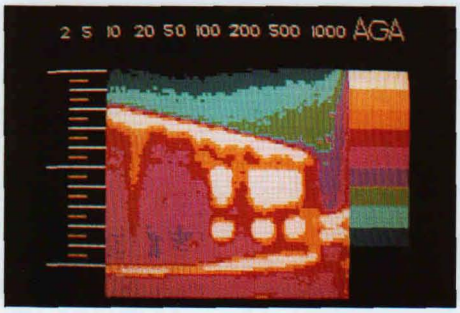
Building Fabric Tests

As part of the Case Study monitoring, an infra-red thermography survey and air infiltration rate test were carried out.

The infra-red thermography survey indicated a generally even level of thermal performance, and thus correctly installed insulation, in both the clad construction and the masonry wall. The difference in insulation levels between the two construction types was clearly evident. The even thermal performance of the round eaves was also indicated. The survey identified possible air leakage at one verge junction, and also indicated that the perimeter of the ground floor slab was acting as a thermal bridge.



Infra-red thermogram of outside front wall showing generally even thermal performance and a higher surface temperature for the brickwork than the metal cladding



Infra-red thermogram of rear end of outside side wall showing evidence of possible air leakage at eaves level and thermal bridging caused by the masonry plinth at the base of the metal cladding panels

The measured U-value of the masonry wall approximated to the design value, allowing for the experimental error for the test.

The air infiltration rate test gave a value of 1.8 ac/h. However, the external conditions during the test were poor, with a strong wind, and this would have adversely affected the measured value. Under normal conditions the building would be expected to achieve the CIBSE recommended empirical value in energy calculations for air infiltration allowance (with natural ventilation) of 1.0 ac/h.

Energy Use

The building is occupied 10 hours/day, 5 days/week. For the year to February 1991, the total annual energy consumption normalised to 2462 degree-days was:

gas	24 189 kWh	(54 kWh/m^2)
electricity	3 329 kWh	(7.4 kWh/m^2)

The total normalised annual energy consumption was 27 518 kWh (61.4 kWh/m^2).

It was estimated that the office space heating accounted for 96% of the gas consumption and the domestic hot water for 2%. The actual total gas consumption was 4% less than the value estimated using the CIBSE Guide method for the same conditions.

Apart from a small amount used for the office equipment, the major use of electricity was lighting. The use of energy efficient fluorescent and SON fittings, all of which are switched off when not in use, contributed to the low electricity consumption of 7.4 kWh/m^2.

With an adjacent, unheated, storage area the office gas consumption for heating was increased, since the internal walls were uninsulated. Based on the CIBSE Guide method, it was estimated that for the office at a temperature of 21°C, the design condition consumption was 52% higher than it would have been with the storage area heated to 16°C.

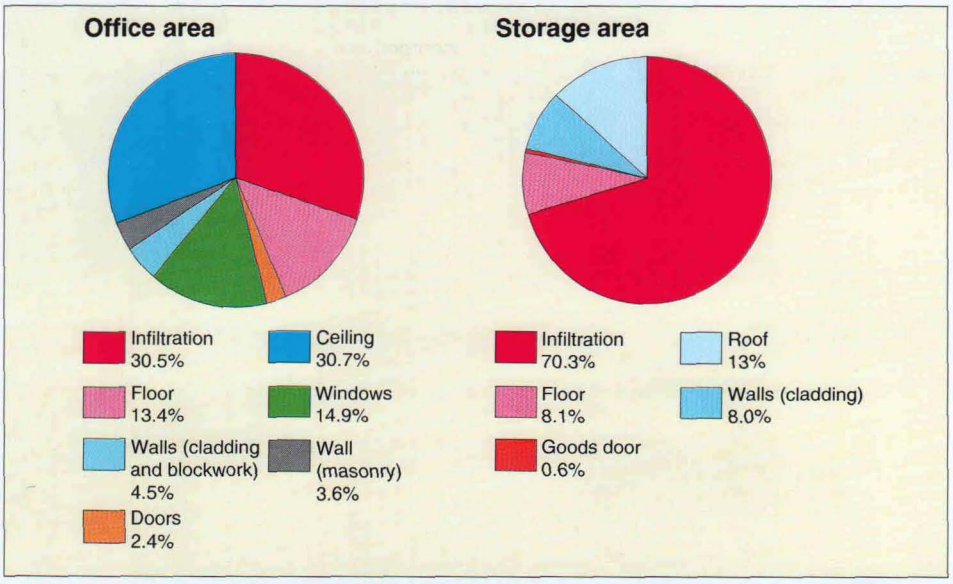
With the storage area heated, the total normalised energy consumption for the building is estimated at 154 kWh/m^2. This corresponds approximately to a 'good' performance rating for a heated warehouse. (Energy Efficiency in Buildings - Factories and Warehouses, EEO 1990.)

Energy Costs

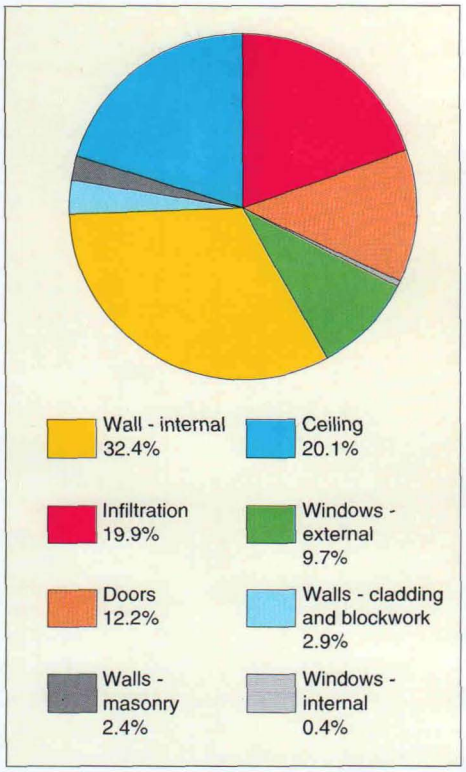
The total annual energy cost was £800 (£1.79/m^2) comprising:

gas	£355
electricity	£445

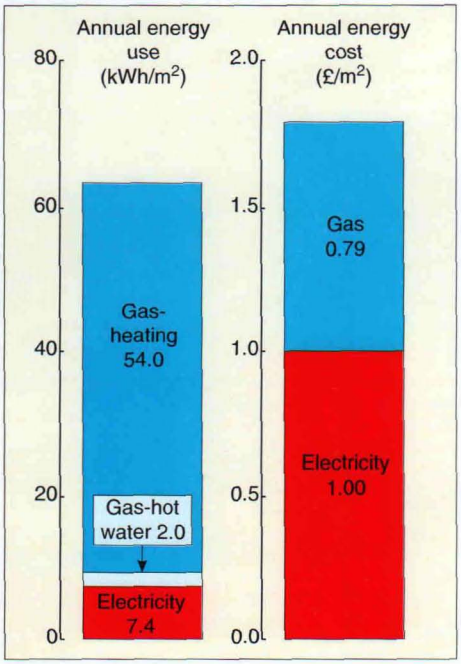
Electricity consumption accounts for 12% of the actual total consumption, and 56% of the total costs.



Distribution of calculated heat loss for office and storage areas with both areas heated



Distribution of calculated heat loss for the office area (with unheated storage area)



Normalised energy use and actual costs

Environmental Performance

In the offices, typical winter daily temperatures were 21° to 23°C and the heat-up rates indicated adequate plant capacity, even on winter mornings at below design condition temperatures.

User Reactions

The occupier operated the services in an energy conscious manner by switching off lights when not in use or when daylight was sufficient, and also by switching off the heating time clock at weekends.

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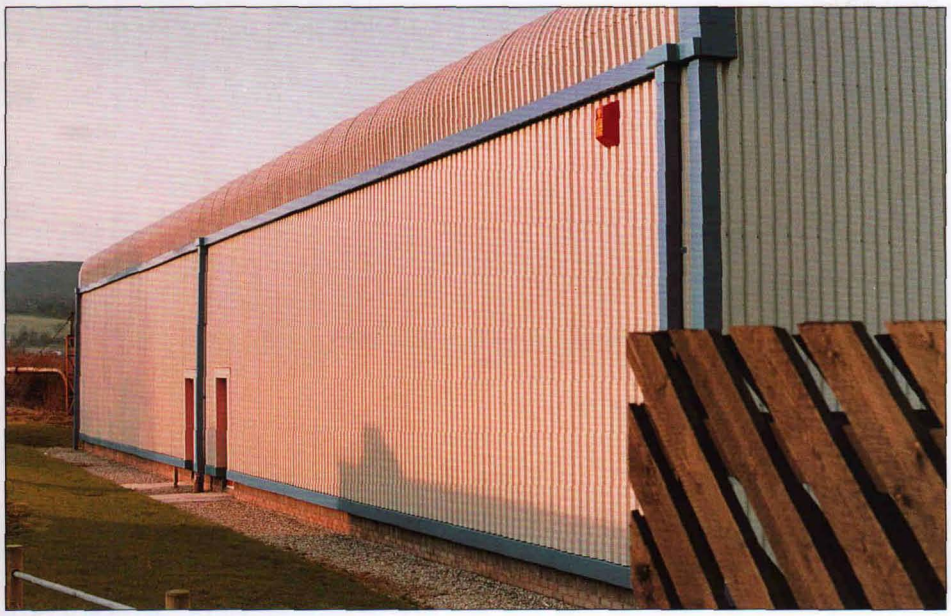

Rear view

The link between the quality of the internal environment and the energy efficiency of the building was recognised. It was considered that staff performance benefited from maintenance of a good quality internal environment.

There was general satisfaction with the building and its systems. However, the space temperature in the ground floor office decreased rapidly when the door into the unheated storage area was opened. A difference in winter temperatures between the ground and first floor offices was commented upon, although this may have been remedied by adjustment of thermostatic radiator valves. On some occasions the first floor office became too hot in summer.

General Appraisal

The building fabric achieved the developer's aim of providing a cost-effective envelope exceeding the minimum thermal performance required by the Building Regulations, with the potential for minimising the energy costs of tenants. Features evolved by the developer over a number of years were incorporated into the design to provide a high quality building at little extra capital cost.

Infra-red thermography confirmed the high standard of design and construction. Only two minor shortcomings were identified – evidence of air leakage at one verge junction, and thermal bridging at the perimeter of the floor slab.

The correspondence between the actual and estimated gas consumption further confirmed that the building fabric was built as designed and that the heating system and controls were being used correctly.

Heating and lighting systems in the building operate efficiently, providing mainly comfortable conditions. There is some fall in the ground floor office temperature with the door open to the unheated storage area. This would be alleviated by installing a draught lobby and additional door into the storage area.

The internal wall between the office and storage areas is effectively an external wall as the storage area is unheated. It should be insulated to reduce still further the energy consumed in heating the office.

Low construction costs of £313/m^2 demonstrate that energy efficiency measures can be commercially viable. The occupier was able to realise benefits from these measures by managing the services in an energy conscious manner.

Other publications on Energy Efficiency in Advance Factory Units from the Best Practice programme:

Good Practice Guides

GPG 61 Design Manual

GPG 62 Occupiers Manual

Good Practice Case Studies

GPCS 106 Barclays Bank plc

GPCS 139 Power Display Signs Ltd

GPCS 140 DBRW Units 5-8 Ystradgynlais

GPCS 141 DBRW Unit 1 Ystradgynlais

GPCS 144 Reed Southern Print Ltd

GPCS 145 Valentec International Ltd

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ACKNOWLEDGEMENT

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